BIMANUAL MANIPULATION PROTOCOL (TASK 1)

Reference No / Version	RAL-SI-2020-P19-0836_1-V1.0 (for the latest versions of the protocol, please refer to: https://www.epfl.ch/labs/lasa/sahr/benchmark/)
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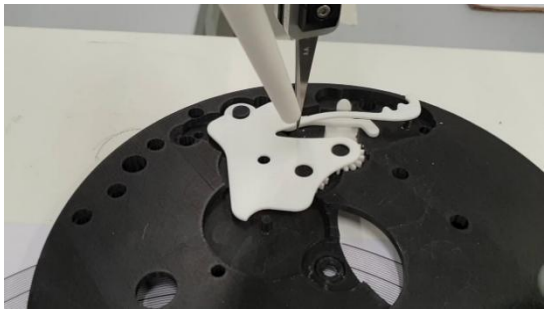
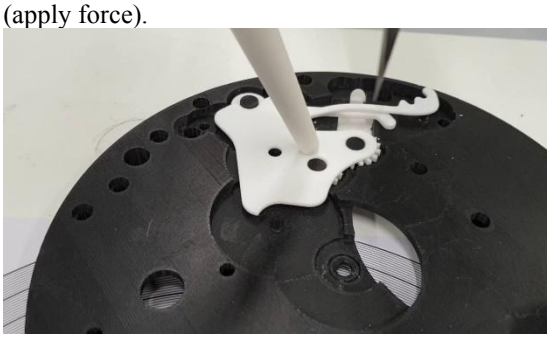
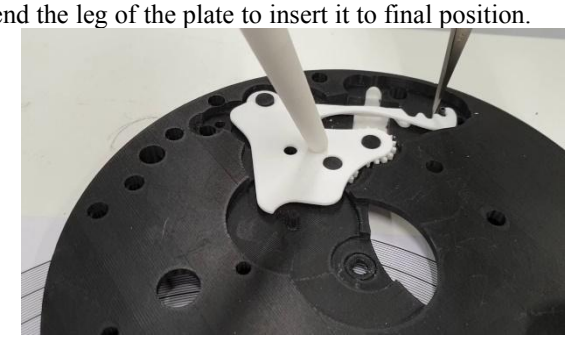
Purpose	Assess the motion planning and/or learning performance of a multi-arm system performing insertions.
Task Description	Insertion of a semi-deformable object with the help of tools.
Setup Description	List of objects and their descriptions: *3D-printed watch face* : CAD model of a Swiss watch is provided; two scaled-up versions are also given, respectively 3.5x and 5.8x larger than the original size. 3D-printable with FDM technology (suggested) or a technology with 1mm precision minimum. *3D-printed plate (and other watch components)* : part of the model provided (see "3D-printed watch face" for details). 3D-printable with SLA technology (suggested) or a technology with 0.5mm precision minimum. *Tweezers* : used to insert and bend the plate into place on the watch face. Note that it may be sufficient to use a standard robotic gripper to replace the tweezers. We hence let users decide if they want to opt for that solution or they wish to have a tweezer mounted on the robot's end-effector. Whichever solution is chosen, we set only as constraint that the tool at the end-effector have the following characteristics: (a) only two legs, and (b) only one translational degree of freedom; hence it can only "pinch". *Wooden stick/Screwdriver* : used to keep the metal plate in its place while hooking its leg into place. Users are allowed to use any "stick-like" tool suited to the size of their robotic set-up. The "stick" should not be actuated (i.e. no degree of freedom) and hence only extend the tip of the robot.
	Initial and target poses of the objects and tools: One robotic arms with tweezers as end effector, already holding the plate. A second robotic arm holding the second elongated tool.
	Description of the manipulation environment: Watch face placed on a flat surface inside the workspace of all robots.
Robot/Hardware/Software/Subject Description	Targeted robots/hardware/software: Two robotic arms, with at least 4 DoFs. Force/Torque sensing not required, but likely useful. Object tracking through computer vision (the participants need to use the one provided by the benchmark) One RGB camera feedback for OFL or ONL approaches (see Benchmark for description of four possible approaches)

	<u>Initial state of the robot/hardware/subject with respect to the setup:</u> Initial state of the robotic arms may be any non-singular state which allow to reach the watch face. One robotic arm already grasping the plate with the tweezers. Initial position of the watch face is chosen by the user.
	<u>Prior information provided to the robot:</u> Initial location of tools and plate is considered to be known a-priori, as they are grasped by the robotic arms. Users can also use (if needed) the kinematic and dynamic models of the robotic manipulators as well as the rigid body version of the watch parts. Additionally, the information that the leg of the plate is semi-deformable can be exploited, although the actual deformation model should not be available (it can be learned or estimated though).
Procedure	Initial plate configuration:  1. Approach the watch-face with both robotics arms. 2. Place the 3D-printed plate with correct position and orientation on the watch face.  3. Release the plate and hold it in place with the second robotic arm (apply force). 

	4. Bend the leg of the plate to insert it to final position.  5. Repeat steps 1-4 for 5 times total. 6. Repeat steps 1-5 for 3 different watch face orientations in total, chosen by the user in the workspace of both robots. 7. Repeat steps 1-6 with the other watch face size. (Please refer to the supplementary video for examples of steps 1-4).
Execution Constraints	None.